

# Calibration & Commissioning

## OBJECTIVE

*Commissioning ensures that all lighting control systems function as close to design intent as possible after installation and before occupancy.*

This is an especially important and mandatory phase of work.



## KEY IDEAS

### General

- **Establish budget, responsibility and commitment to commissioning from the earliest project phase.** Plan for this critical step from the beginning. Identify special areas of concern to the commissioning phase as they arise during programming and design phases.
- **Solve problems before occupancy through commissioning.** Many operations problems are there from start-up. Successful commissioning eliminates these problems before occupants arrive and gets the building off on the right track.
- **Use the commissioning phase also as a training period for Operations and Maintenance (O&M) staff.** Use this time to acquaint O&M personnel with building systems.
- **Carefully follow all appropriate commissioning steps.** This is a general sequence of activity:
  1. Visually inspect that each piece of equipment is in the right place, installed correctly, and calibrated to meet design specifications.
  2. Verify that all sensors have been properly placed.
  3. Verify local control of each piece of equipment.
  4. Test interactions between equipment pieces.
  5. Test system-wide operation under different anticipated scenarios.
- **Do not end the commissioning phase until the building is handed off to O&M personnel.** A successful hand-off includes:
  - Documentation of building systems for O&M staff use.
  - Description of O&M plans, schedule, and responsibilities.
  - Performance standards for all building systems.
  - Training of O&M staff.
- **Leave adequate documentation behind for O&M staff.** The following materials should be left on file in the building, easily accessible and in an easy-to-use format:
  - An index or directory of all documents on hand.
  - Equipment specifications, line diagrams, manufacturer's warranties, and contact information.
  - Operating manuals.
  - Maintenance procedures.
  - Test, calibration, and balance reports.
  - All construction documents, including as-builts.
  - Emergency procedures.

## ***Calibrating Lighting Controls with Photocell Sensors***

- **Establish baseline conditions.** Calibration will set the relationship between the light level detected by the control photosensor and the output of the electric lights that the photosensor controls.
- **Make sure actual electric lighting is as expected.** The response of any light-sensing control system must be calibrated after installation to ensure that the response of the electric lighting system is appropriate to the design lighting conditions in the building space.
- **Make sure actual daylighting is as expected.** The daylight levels in any space are highly dependent on local conditions (window size and transmittance, shading device and strategy, percentage of clear versus cloudy hours, room reflectances, etc.). It is not possible to “factory set” daylight linked controls and obtain optimum or even acceptable control system response without calibrating the system response upon installation.
- **Make sure system is in good working order.** Calibrating the system helps to uncover any installation errors and provides an opportunity for the system to be repaired before the vendor leaves the job.

### ***When to Calibrate Lighting Controls***

- **As soon as possible after system completion.** While it is better to commission after the furniture is in place, fine tuning can be done later when tenant improvements are made.
- **Lumen maintenance calibration should be performed shortly after installation,** after initial breaking in of lamps (fluorescent lamps should be burned for at least 100 hours at full light output to ensure stable lamp operation). In a retrofit installation, fixtures should be cleaned, relamped, and lamps burned in prior to calibration.
- **Re-calibrate after changes in a space.** Photosensors must be re-calibrated when room paint, carpet, wall art or furniture is modified.
- **For an open-loop system, calibrate during the day** when the sun is shining and not blocked by clouds (unless overcast skies predominate the region). There should be no direct sun shining into the space. Choose a time when daylight is plentiful but not enough to meet the design illumination without some supplemental electric lighting. There should be enough daylight to cause significant but not full dimming of the electric lights.
- **For a closed-loop system, calibrate at night.**
- **Coordinate lighting commissioning with other subsystem commissioning activities (e.g., mechanical system).**

## ***How to Calibrate Lighting Controls***

- **In general, follow manufacturer’s calibration instructions**, or request that commissioning be included with installation. Commissioning of controls generally requires specialized knowledge and skills. The following guidelines may be additionally useful for experienced electricians.
- **Calibrate each independently controllable zone (control group) separately.**
- **Select an appropriate stationpoint in each zone.** For each control zone, select one location that is representative of the daylighting and electric lighting conditions for that entire zone. This might be a desk that is a “typical” distance away from the nearest windows. A desk within eight feet of the control photosensor is a particularly convenient choice. These selected locations (at desktop height, or 30” above the floor, typically) are known as “stationpoints.” For large control zones (over 500 square feet), it may be desirable to use more than one stationpoint to represent the entire zone. For an open plan space with partitions, select the partitioned space nearest the photocell.
- **Open-loop calibration requires daylight.** If the system is open-loop, you must calibrate when there is daylight. See “when to calibrate” above. Calibrate an open-loop system as follows:
  - Have occupant adjust any window shades to a comfortable position. (If no occupant, use your best judgment).
  - If the system has a “maximum light” adjustment, have an assistant cover the photocell. Place your photometer at the stationpoint and adjust the output of the electric lights until the photometer reads the design light level (typically 500 lux, or 50 footcandles for office tasks). It may take up to a minute for the system to respond to the photocell being covered.
  - If system has a “minimum light” adjustment, uncover photocell and shine a flashlight on control photosensor. Use an assistant if necessary. After a minute, observe nearby fixtures; they should be substantially dimmed. If any appear to be flickering or unstable, increase the “minimum light” adjustment until flickering just disappears.
  - Now check the system sensitivity by uncovering the photocell and waiting a minute until the electric lights stabilize. Observe the reading on the photometer at the stationpoint. Adjust the sensitivity (adjustment typically at photocell or wall-mounted control box) until the photometer reads the design light level (typically 50 footcandles).

- Check the robustness of the calibration by adjusting the blinds and see if the photometer still reads the design light level. It should, to within a few footcandles.
  - Now use your eyes to check for comfort. Does the space appear gloomy or uncomfortably dim? If so, adjust the system sensitivity so that the photometer reads slightly higher than the design level (perhaps another 10 footcandles).
  - Mark up the reflected ceiling diagram to record stationpoint locations and a log for the readings, so that calibration can be checked from time to time after occupancy.
- **Closed-loop systems require nighttime calibration.** Calibrate a closed-loop system as follows:
    - Turn on the electric lights and adjust the setpoint until the electric lights are at maximum intensity. Verify this by checking the photometer at the stationpoint. Note this maximum light level reading. It should be about 40% over the design light level, assuming a 70% maintenance factor, new lamps and clean fixtures. Wait until thermal stabilization has been reached. This can take up to one hour. Recheck maximum reading. Now back off on the setpoint until the photometer reads 70% of the maximum reading.
    - If system has a “minimum light” adjustment, uncover photocell and shine flashlight on control photosensor. Use an assistant if necessary. After a minute, observe nearby fixtures; they should be substantially dimmed. If any appear to be flickering or unstable, increase the “minimum light” adjustment until flickering just disappears.
    - Mark up the reflected ceiling diagram to record stationpoint locations and a log for the readings, so that calibration can be checked from time to time after occupancy.
    - Return during the day with your photometer and do some spot checks at various stationpoints. They should read close to the design light level. Increase light level as appropriate to avoid dark workstations.

### ***Commissioning Automated Shades, Blinds, or other Window Coverings***

- **Follow manufacturer’s instructions** or request that commissioning be included with installation.
- **File any maintenance literature.** Keep manufacturer’s recommended maintenance procedures for the shades on file with other O&M documents.

## INTEGRATION ISSUES

### ARCHITECTURE

Calibration and commissioning activities have little impact on architectural design. If architect is coordinating all construction documents (CDs), ensure that calibration and commissioning plans are included in the CDs. The same goes for maintenance plans.

### INTERIOR

Coordinate schedule of interior completion with the commissioning schedule. System calibration is better accomplished if furniture and finishes are already in place.

### HVAC

Commissioning is an important phase for proper mechanical systems operation in a high performance building. Commissioning is especially important with advanced control systems.

### LIGHTING

Daylighting controls require calibration. Other lighting controls (not covered in these guidelines) should also be evaluated in the commissioning phase.

### COST EFFECTIVENESS

Cost effectiveness of daylighting relies on proper operation of lighting controls and satisfaction of occupants. Calibration is critical for maintaining the value of any added investment for daylight design.

In general, commissioning has been shown to very cost effective in the few buildings documented.

### OCCUPANT COMFORT

Check that occupants are satisfied with the lighting controls. If not, they may disable the system. Adjust the controls in response to occupant feedback. If occupants are resistant to automated controls, or if occupants dislike working under daylight alone, educate them as to the environmental benefits of daylighting. Explore the source of their dissatisfaction before their minds are set against daylight controls.

## PROVISOS

- *CAUTION:* Any electrical work must be performed by qualified personnel, following all appropriate safety procedures.
- Commissioning is a relatively new procedure not yet standardized. The design and construction industry is still working out how to do it, who should do it, and how it integrates with the construction and O&M phases. Make sure the building owner understands the benefits of proper commissioning.
- If the lighting system is calibrated before furniture is installed, control system response after occupancy could be unsatisfactory and would have to be re-calibrated.
- Calibration procedures vary from system to system. Guidelines given here should be used as general protocol only. Always follow manufacturer's calibration procedure first, then consult these guidelines for additional information. If there is a contradiction between the two, manufacturer instructions take precedence. Contact the manufacturer for clarification, if necessary.

- Commissioning generally requires specialized knowledge and skills. Hire someone qualified to make electrical adjustments. Control systems often contain high voltages that may be lethal.
- When controls are not functioning properly, occupants will disable them.
- Do not forget to re-commission after major changes such as space conversions, retrofits, and equipment replacements.

## TOOLS & RESOURCES

- **Manufacturers** This is generally the only source of assistance available for calibration of daylighting controls and commissioning of advanced HVAC control systems. It is advisable to make an agreement with the supplier regarding proper installation and calibration to design specifications. In fact, manufacturer selection might be based on the level of calibration support promised.
- **The National Environmental Balancing Bureau (NEBB)** (301) 977-9589 has a Procedural Guideline and also certifies firms that provide commissioning services.
- **ASHRAE** The American Society of Heating, Refrigerating and Air Conditioning Engineers offers a wide range of technical support materials for mechanical systems, including the monthly *ASHRAE Journal*. Up-to-date commissioning guidelines are often found in this literature. Call 800-527-4723 for a publications list. For *ASHRAE Journal* subscription information, call above number or 404-636-8400.
- **AEE** The Association of Energy Engineers publishes a number of periodicals on subjects ranging from energy management to lighting efficiency and environmental compliance. Call (770) 447-5083 for a publications list, or visit the AEE world wide web site at <http://www.aeecenter.org>.
- **Books** *ASHRAE Applications Handbook* (American Society of Heating, Refrigerating and Air Conditioning Engineers 1991) is a good source for testing, adjusting and balancing procedures. See also ASHRAE Guideline 1-1989, *Guideline for Commissioning of HVAC Systems*.
- **Utility Company** Some utilities offer incentives for commissioning in both new and retrofit projects. Inquire at your local utility about these programs.
- **Lighting Calibration Tools** Recommended tools for calibrating lighting controls:
  - Photometer in recent calibration (need not be expensive).
  - Powerful flashlight.
  - Opaque material to cover photosensor.
  - Reflected ceiling diagram showing locations of control zones.
  - Walkie-talkies if calibration controls are not line-of-sight with control zone(s) to be calibrated.
- **Diagnostic Tools** Calibration and commissioning are greatly assisted by appropriate measurement tools. A variety of devices ranging from data loggers to hand-held survey instruments can measure everything from simple dry bulb temperature to building power consumption. Many tools are inexpensive and easy to use. A good source for information is the monthly *Sensors Magazine*. Subscription information: PO Box 1285, Northbrook, IL 60065-1285. Publisher: Helmers Publishing, Inc., 174 Concord St., PO Box 874, Peterborough, NH 03458-0874, (603)924-9631.
- **Consultants** Specialized or unusual sensors and controls may require particular expertise. If the product manufacturer(s) will not provide assistance beyond installation, an outside specialist in calibration or commissioning activities may be advisable.

## CHECKLIST

1. Establish time, budget and responsibilities for the commissioning phase early in the building design process.
2. Have operation and maintenance staff on board during commissioning, for training.
3. Gather all building documentation, including the operation and maintenance plan and the system performance standards, in an orderly file, preferably stored in the building operator's office.
4. Confirm system performance standards (design light level, for example) before proceeding with calibration.
5. Review all calibration and other commissioning steps outlined in the construction documents with installers. These steps should follow the guidelines presented above, unless manufacturer instructions indicate otherwise.
6. Calibrate lighting controls after interior finishes and furniture are in place.
7. Commission HVAC system anytime after installation.
8. Commission automatic shades, if any, immediately after installation with help from the manufacturer/installer.
9. Verify proper interactions, if any, between those three systems.
10. Check occupant comfort and satisfaction shortly after occupancy. In particular, ensure occupants understand the purpose of automated lighting controls and will not disable them.
11. Commissioning team should remain available until the O&M staff is comfortable with all building systems, and the building is functioning as close to design specifications as possible.
12. Keep any tools acquired for calibration, such as a photometer, for use by O&M staff.

### If you have...

#### no time

1. Be sure all systems are installed per design and manufacturer specifications.
2. Follow lighting calibration instructions given here, with assistance from the manufacturer if possible.
3. Be sure all available building and product documentation available is on file in the building.

#### a little time

In addition to above:

1. Perform a thorough daylighting calibration. Secure agreement from manufacturer for assistance before purchase.
2. Have the mechanical system commissioned as thoroughly as budget allows, perhaps through some cooperative effort of manufacturer, installer and mechanical engineer. At a minimum, ensure space conditions are as intended.

#### more time

In addition to above:

1. Establish a dedicated commissioning team with appropriate expertise in daylighting controls, mechanical commissioning and energy management control systems. This team should include representation from controls manufacturers.
2. Commissioning phase should overlap both installation and occupancy. Commissioning team should be involved in training of O&M staff.
3. Include a comfort evaluation shortly after occupancy in the commissioning phase. This should also address any dissatisfaction or misunderstanding among occupants about the lighting controls.